COMPUTER-BASED INSTRUMENTATION SYSTEM FOR TEMPERATURE MEASUREMANT USING THERMOCOUPLE IN VISUAL BASIC APPLICATION

(C.I.S.T.V.A)

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Specially dedicated to

My beloved parent

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Assalamualaikum.

ABSTRACT

In this project, Visual Basic is used as a main programming language to develop a GUI (Graphical User Interface) application. This application is developed to help student in studying the industrial instrumentation subject. For this project, thermocouple sensor type K will be used as an input device to detect temperature changes. The input will be converted into current signal between 4 - 20mA. Then, a DAQ card will be used to interface between the instrument and computer. The software is divided into 4 sections, data preview, data control, application and setting. Data preview section is used to preview live data from DAQ card. When the data is completely recorded, the data is manipulated to get appropriate result and graph, using data control section. In application section, some useful applications have been added for student such as converter, uncertainty calculation, graph generator, live graph, export data, data recorder and data plotter. And the setting section has function for software's setting.

ABSTRAK

Dalam projek ini, Visual Basic digunakan sebagai bahasa pengaturcaraan utama untuk membina aplikasi AGP (Antaramuka Grafik Pengguna). Aplikasi ini dibangunkan untuk membantu pelajar dalam subjek Industrial Instrumentation. Untuk projek ini thermocouple jenis K akan digunakan sebagai alat untuk mengesan perubahan suhu. Input akan ditukar kepada signal arus dalam 4-20 mA. Kemudian, DAQ akan digunakan untuk mengantaramuka antara komputer dan peralatan. Perisian ini dibahagiakan kepada 4 bahagian, iaitu data pratonton, data kawalan, aplikasi and tetapan. Bahagian data pratonton digunakan untuk melihat data secara langsung dari kad DAQ. Apabila data telah sepenuhnya direkodkan, data akan dimanipulasi untuk mendapatkan keputusan dan graf yang sepatutnya menggunakan bahagian data kawalan. Dalam bahagian aplikasi, aplikasi yang berguna telah ditambah untuk pelajar seperti pengubah, kiraan ketikpastian, penjana graf, graf langsung, data ekspot, perakam data dan pemplot data. Dan bahagian tetapan mempunyai fungsi untuk tetapan perisian.

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, the major change occurring at the present is the increasing number of user friendly software that make it possible for student to experience new and fast ways of learning. In minutes, simulation, controller and real world interfacing can be created instantly. The software is developed to help students to learn and explore the experiment with an interesting and interactive way.

In this project, Visual Basic will be used as a main programming language to develop a GUI (Graphical User Interface) application. This application is developed to help student in studying the industrial instrumentation subject.

For this project, thermocouple sensor type K will be used as an input device to detect temperature changes. The input will be converted into current signal between 4 - 20mA. Then, a DAQ card will be used to interface between the instrument and computer.

The software will be developed using Visual Basic to calculate and analyse the output. Visual basic software does all the manipulation, analysis and report generation.

1.2 Objectives

There are three main objectives of the project which are:-

1. To understand basic measurement principal of temperature instrumentation. For this project, the instruments that will be used consist of several parts. This part is important because it is an input for the system and required deeper knowledge and understanding.

2. Interface the temperature transmitter output to software application. The interface process is done with Data Acquisition process (DAQ). DAQ card will be used to interface between instrument and computer.

3. Develop software application to help in student learning process. Visual Basic 2008 Express Editon will be used as a main programming language. The software is developed to be interactive and user friendly to the user. And the software will be used during lab session of Industrial Instrumentation subject (BEE4523) to help in student learning process.

1.3 Scopes

This project involves designing the software application to analysis the data using Microsoft Visual Basic 2008 Express Edition. USB Data Acquisition (USB-4716) is used to interface between the computer and temperature instrument such as temperature transmitter, hart communicator and digital manometer. Thermocouple type K is used as a primary transducer to detect temperature changes in Isotech Jupiter temperature bath.

1.4 Research Methodology

i) Literature review to understand the concept and identify the problems and techniques.
ii) Understand the whole system especially how to communicate between PC and instrument.
iii) Design and writing program according to lecturer needs and understanding of the system.
iv) Interface between computer and thermocouple through USB-4716DAQ card
v) Test the software and verify the result with manual calculation.

Design step of work methodology can be simplified as shown in Figure 1.1

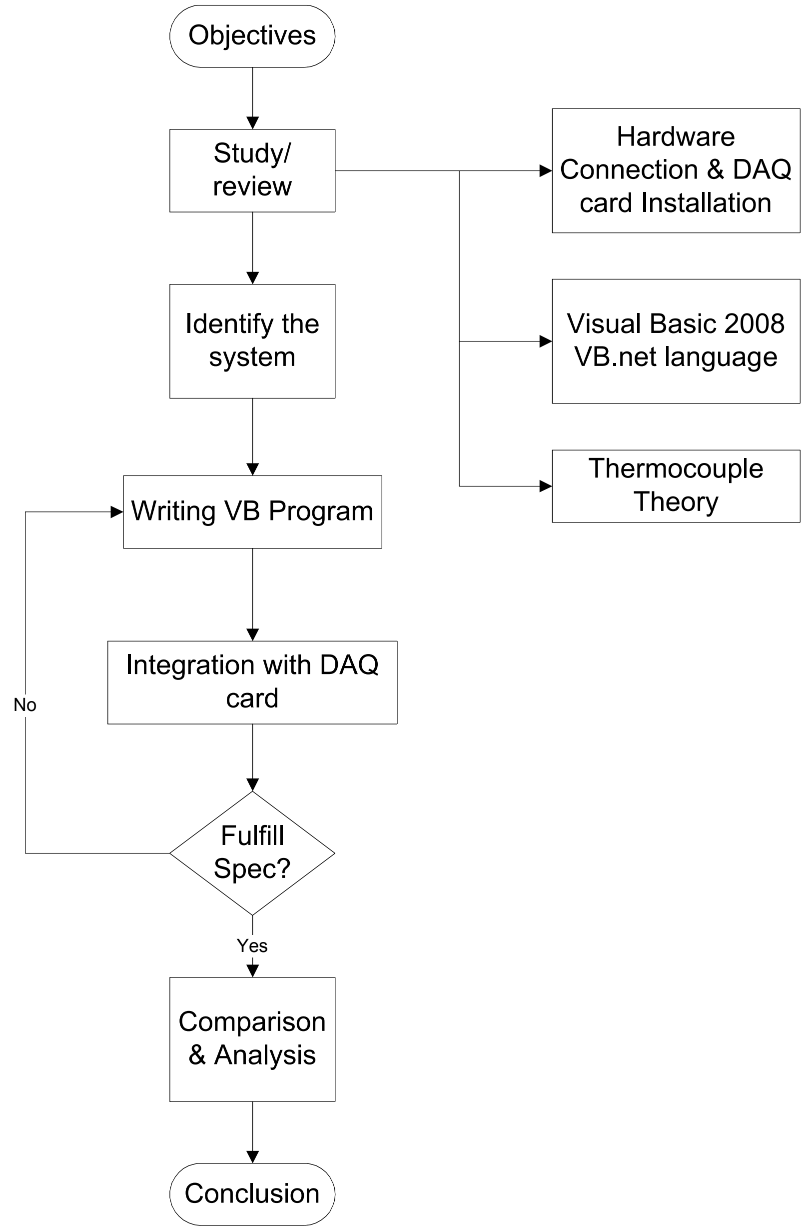

Figure 1.1: Design Flowcharts.

CHAPTER 2

LITERATURE REVIEW

2.1 Evaluation of the Freezing Point of Zinc for Pt/Pd Thermocouple Calibration

This research was conducted by H.Narushima*, H.Ogura, M.Izuchi and M.Arai from National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology (NMIWIST). In this research, a new apparatus was developed to calibrate thermocouple at zinc freezing point. The stability of the temperature repeatability as well as effect of surroundings temperature was also investigated as uncertainty components.

With the rapid globalization of economic activities and borderlessness of industry, many kinds of products are assembled by parts from several countries. To this concern, measuring instruments traceable to national standards for these products and parts are essential. In the field of measuring instruments, a lot of thermocouples are widely used. To calibrate these thermocouples accurately, several fixed points (Cu, Ag, AI) apparatuses have been developed"' since 2000 at NMIJ. The zinc fixed-point apparatus was needed to calibrate thermocouples from 0°C to 1100°C [5].

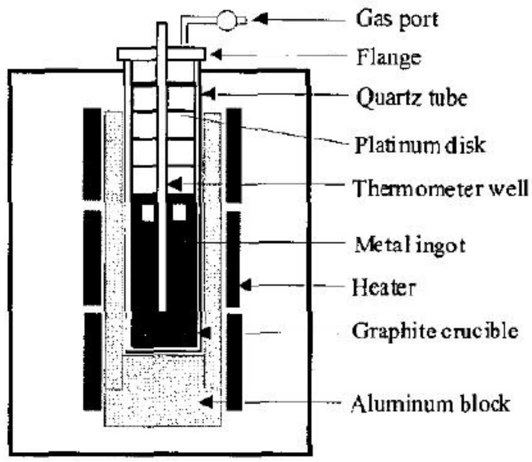

Figure 2.1: Zinc Freezing Point Furnace

Schematic view of the zinc freezing point fumace is shown in Fig.1. The zinc freezing point cell installed in the aluminum isothermal block is heated hy a three-zone heater. To reduce the electromagnetic noise during measurement, the sheathed heaters are wound noninductively and supplied by DC power. The zinc freezing point cell is an open type filled with pressurized argon gas whose pressure is measurable.[5] To measure the emf of thermocouples, reference junction is generally maintain at 0°C in an ice bath.

At the start of estimating zinc freezing point realization apparatus, an automatically operating ice-point device was used to maintain the temperature of the reference junction. But, on and off of the electronically cooling in the automatically operating ice-point device induced the temperature up and down to the reference junction [5].

In this experiment Pt/Pd thermocouples were used, because they show outstanding stability compared to the conventional thermocouples.

2.2 An Automated Thermocouple Calibration System

An Automated Thermocouple Calibration System was invented by Mark D. Bethea and Bruce N. Rosenthal. It was developed for calibration type K thermocouple.

This system operates from room temperature to 650°C and has been used for calibration of thermocouples in an eight-zone furnace system which may employ as many as 60 thermocouples simultaneously. It is highly efficient, allowing for the calibration of large numbers of thermocouples in significantly less time than required for manual calibrations. The system consists of a personal computer, a data acquisition/ control unit, and a laboratory calibration furnace. The calibration furnace is a microprocessor-controlled multipurpose temperature calibrator with an accuracy of f.7"C. The accuracy of the calibration furnace is traceable to the National Institute of Standards and Technology (NIST). The computer software is menu-based to give the user flexibility and ease of use. The user needs no programming experience to operate the systems [6]. The purpose of calibration is to determine if the thermocouple being tested are within the standard. If the thermocouple is outside the standard, a proper calibration must be made.

The calibration of a thermocouple consists of the determination of its electromotive force (emf) at a sufficient number of known temperatures so that with some means of interpolation, its emf will be known over the temperature range in which it is to be used. This process requires a standard thermometer to indicate temperatures on a standard scale, a means for measuring the emf of the thermocouple, and a controlled environment in which the thermocouple and the standard can be brought to the same temperature [6]. The standard thermometer can be considered as MSU (Master Standard Unit). Usually digital thermometer and RTD is used as MSU because it has high accuracy and fast response.

To calibrate thermocouples by the temperature comparison method, the thermocouples are placed in a special calibration furnace which provides a stable, repeatable environment. The heating block inside the furnace has a high thermal conductivity and is heated by resistance elements. The temperature is controlled by a precision platinum resistance thermometer (RTD sensor) and a closed-loop circuit [6].

Using the ATCS, the experimenter needs only to be present at the beginning and end of a calibration session. If a thermocouple is to be calibrated at five different temperatures, the experimenter simply specifies those temperatures at the start of the calibration and then returns when all five temperatures have been reached and the calibration session is complete [6]. This benefit of this system is it can save a lot of time for calibrating thermocouples and reduce the cost. This system can be applied in industry that uses a lot of thermocouples.

2.3 High Speed PC-based Data Acquisition Systems

Until recently, within the last three years, high speed data acquisition systems which guaranteed data integrity could only be implemented on high end platforms such as VAX/VMS or U N I X systems. These provided sophisticated multitasking operating systems and enough horsepower to not only provide data collection of tens of thousands of U 0 points, but also provide graphical interfaces to users. These systems were, and still are, expensive to buy and maintain [7].

Data collection on PCs has been, and continues to be, rather disappointing for users who demand high speed sampling, data integrity, and data storage. This has been due to a combination of the lack of CPU power, the lack of sophistication of PC operating systems, and the slow speed of peripheral devices such as disk drives. Therefore, many users are reluctant to leave their high end systems and look at what can be done on the PC platform [7]. Recent availability of powerful PC hardware and software has now made it possible for the PC platform to match the data acquisition performance of traditional high end systems.

The first step in designing and implementing a flexible, high speed data acquisition system on the PC platform is to specify a set of goals which the system must achieve. This section lists these goals, and also how most other PC systems fail to meet them. The failure of these existing systems to meet these goals is what separates them from the PC system being designed [7]. Thus, the following goals are discussed.

2.3.1 Guaranteed high speed data acquisition

First, the system must support high speed data acquisition. High speed processes, such as variable speed drive control, and steel rolling, demand high speed data acquisition. Sample intervals of 20 milliseconds to 50 milliseconds are the goal of the system being discussed here. Also, to meet the data demands of modern production machinery, the system must be able to provide this sampling for up to 10,000 analog and digital values from the monitored system [7].

2.3.2 Minimized channel skew

Skew refers to drifting in time from the specified sampling interval. For example, reading a 20ms sample at 18ms since the last sample or at 22ms since the last sample means that a 2ms skew has been introduced into the data collection. When skew approaches the sample interval, detecting cause and effect relationships using trended and exception data becomes impossible [7]. You can think of the channel skew as the time it takes the analog input subsystem to sample a single channel.

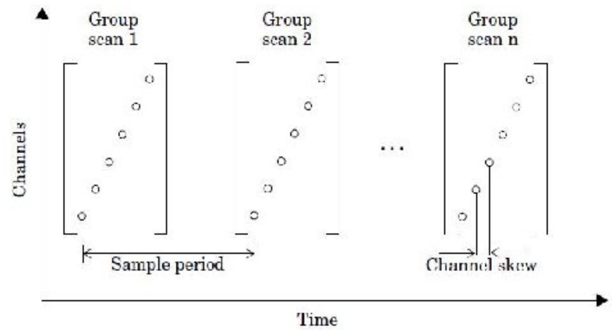

Figure 2.2: Channel Skew

Not only must skew be minimized from sample to sample, but also within samples. For example, skew is introduced into a sample if the system interrupts its sampling to perform an operator task such as responding to a mouse click. Introducing skew within a sample makes the data collected in that sample questionable, and there is no way to tell that the skew was introduced [7].

2.3.3 High Speed Response

In order to monitor high speed processes, the PC platform must be powerful enough to support the running software. This includes components such as the microprocessor, peripheral devices like the disk drive and video accelerator, and memory capacity. Powerful PC platforms have become available only within past several years. Also, the operating software must be sophisticated enough to take advantage of provided platform [7].

This goal must be met in order to provide a useful operator interface. Graphical elements on the screen should update fast enough to emulate analog display devices, such as bar graphs. If these graphical elements cannot update this quickly, problems in the monitored process can be masked [7].

2.3.4 Data Acquisition Functionality

The system must provide all expected data acquisition functionality, such as fault and alarm management, and trending. This functionality must be provided at the sampling rates being supported, and for suitable lengths of time, for example, storing trended data for several days [7].

Indeed, one of the goals of the system is to provide trending for up to 1,000 digital and analog values continuously and simultaneously [7]. This will allow maintenance personnel to diagnose a problem without having to specify which values to trend beforehand.

2.3.5 Hardware

The hardware of the PC system is the foundation of high speed data acquisition and storage. The most sophisticated operating software cannot provide the required functionality if the hardware cannot run it fast enough. As mentioned previously, it is only in recent years that hardware powerful enough for this system has become available [7]. A very powerful PC platform can be put together today for less than RM 2000. The base platform for the PC system being designed here is a desktop PC. The minimum requirement for Data Acquisition System is:

- 2 GHz microprocessor
- 1 GB RAM
- 60GB Hard Drive
- Graphic Card

2.3.6 Operating System

The operating system provides the environment in which all of the PC system software runs. It controls which competing software tasks can have access to the underlying hardware, including the CPU. It also controls when tasks can access the hardware. Different operating systems control access differently. In the PC environment, either “cooperative” multitasking or “preemptive” multitasking is provided [7]. Nowadays, most PC use Microsoft Windows as their operating system. Engineering software such as MatLab, LabView only support Microsoft Windows as their operating system and sometimes we can only find driver for Microsoft Windows.

2.4 Thermocouple

2.4.1 Thermocouple

The basic theory of a thermocouple is found from a consideration of the electrical and thermal transport. When the temperature changes at the junction formed by joining two unlike conductors, its electron configuration changes due to the resulting heat transfer. This electron reconfiguration produces a voltage (emf or electromotive force), and is known as Seeback effect. Two junctions or more of a thermocouple are made with two unlike conductors such as iron and constant an, copper and constantan, chrome and alumel, and so on. One junction is place in a reference source (cold junction) and the other in the temperature.[1]

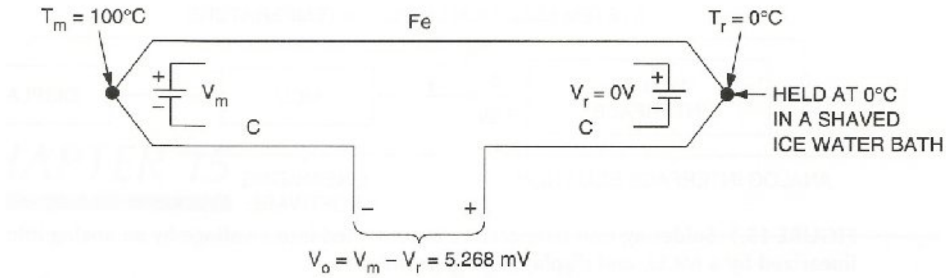

Figure 2.3: Thermocouple Junction

One junction in Figure 1.0 is placed in a shave ice bath and the temperature is 0°C. This junction is reference or cold junction and its thermoelectric reference voltage is defined as V_r = 0V. Temperatures are measured with respect to T_r by the remaining measuring junction, T_m. If T_m is placed in boiling water at T_m 100°C, V_o will equal 5.268mV with the polarity shown in figure 1.0.[1]

2.4.2 Thermocouple types

Thermocouples consist of many types, such as type J, K, T, E, S, and R. Each type has its particular features, such as range, linearity, inertness to hostile environment and sensitivity. In each type, various sizes of conductors may be employed for specific cases such as oven measurement.[3] Thermocouple is considered as transducer. Transducers and sensors convert a real world signal into measurable electrical signal, such as voltage or current. A thermocouple will produce a voltage difference that increases as the temperature increases. For this project thermocouple type K will be used as it is the most commonly used thermocouple.

Table 2.4: Thermocouple type

Type	Materials	Normal Range
J	Iron-constantan	-190°C to760°C
T	Copper-constantan	-200°C to 371°C

K	Chromel-alumel	-190°C to 1260°C
E	Chromel-constantan	-100°C to 1260°C
S	90% platinum+ 10% rhodium-platinum	0°C to 1482°C
R	87% platinum + 13% rhodium-platinum	0°C to 1482°C

2.5 Data Acquisition

Data acquisition is a process of gathering and sampling signals from real world to generate data which can be stored, analyzed, and presented by a PC. Generation of these signals from the real world is through instruments and sensors, and each type of signal needs its own special consideration. Simple ways to store data use a strip-chart recorder or an x-y plotter. But for modern instruments, digitized data is essential for later analysis and storage purposes. Digital system samples all data collected from the instruments, takes average of the data and gives an improved value of the measured signal. Many instruments digitize and store data in their inbuilt memory which can later be transferred to a computer. Other instruments use certain software for data acquisition and control. [2] Data acquisition is a process used to convert a signal in analog to digital so the computer can understand thus process the signal in computer language.

A transducer is an electronic device that converts energy from one form to another. Common examples include microphones, loudspeakers, thermometers, position and pressure sensors, and antenna. Although not generally thought of as transducers, photocells, LEDs (light-emitting diodes), and even common light bulbs are transducers [6].The ability of a data acquisition system to measure different phenomena depends on the transducers to convert the physical phenomena into signals measurable by the data acquisition hardware. Transducers are synonymous with sensors in DAQ systems. There are specific transducers for many different applications, such as measuring temperature, pressure, or fluid flow. DAQ also deploy various Signal Conditioning techniques to adequately modify various different electrical signals into voltage that can then be digitized using ADCs. [3]

Signal conditioning may be necessary if the signal from the transducer is not suitable for the DAQ hardware to be used. The signal may be amplified or deamplified, or may require filtering, or a lock-in amplifier is included to perform demodulation. Various other examples of signal conditioning might be bridge completion, providing current or voltage excitation to the sensor, isolation, linearization, etc.[3]

2.6 Visual Basic

Visual Basic (VB) is a third-generation event-driven programming language and associated development environment (IDE) from Microsoft for its COM programming model. [9]

Visual Basic was designed to be easy to learn and use. The language not only allows programmers to create simple GUI applications, but can also develop complex applications as well. Programming in VB is a combination of visually arranging components or controls on a form, specifying attributes and actions of those components, and writing additional lines of code for more functionality. Since default attributes and actions are defined for the components, a simple program can be created without the programmer having to write many lines of code. Performance problems were experienced by earlier versions, but with faster computers and native code compilation this has become less of an issue [9].

A programmer can put together an application using the components provided with Visual Basic itself. Programs written in Visual Basic can also use the Windows API, but doing so requires external function declarations.

The latest version of Visual Basic is Microsoft Visual Basic 2008 Express Edition.

2.7 Calibration

Calibration is the process of establishing the relationship between a measuring device and the units of measure. This is done by comparing a device or the output of an instrument to a standard having known measurement characteristics. For example the length of a stick can be calibrated by comparing it to a standard that has a known length. Once the relationship of the stick to the standard is known the stick is calibrated and can be used to measure the length of other things.[9]

2.8 Standard Deviation

The standard deviation is a measure of the dispersion of a set of values. It can apply to a probability distribution, a random variable, a population or a multiset. The standard deviation is usually denoted with the letter σ (lowercase sigma). It is defined as the root-mean-square (RMS) deviation of the values from their mean, or as the square root of the variance. [9]

This calculation is described by the following formula:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

Where the mean of X is define as:

$$\overline{x} = \frac{x_1 + x_2 + \cdots + x_N}{N} = \frac{1}{N}\sum_{i=1}^{N} x_i.$$

CHAPTER 3

INSTRUMENTS AND HARDWARES

3.1 Overall System Connection

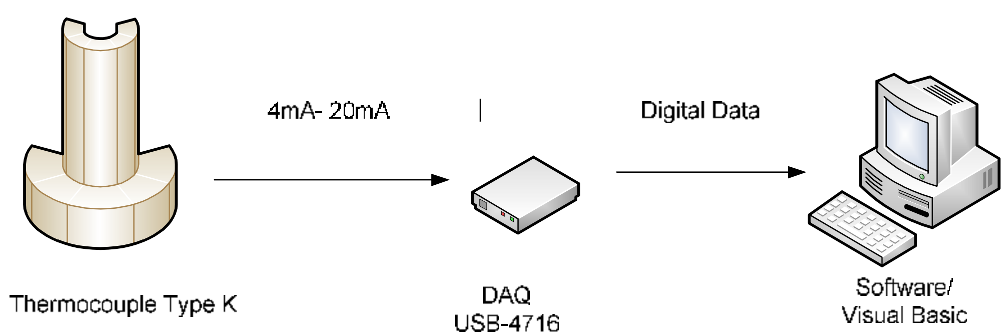

Figure 3.1: Overall system connection

Figure above show the overall system connection for this project. There are three major parts:

i. Thermocouple Type K- Thermocouple will detect temperature changes and then transmit the value in voltage form to DAQ.

ii) DAQ USB-4716 – DAQ is used to convert analogue data to digital data.

iii) Software – Visual basic is used to stored, saved and analysis the data.

Thermocouple and DAQ card is considered as hardware part in this project.

3.1.1 Basic instrument connection

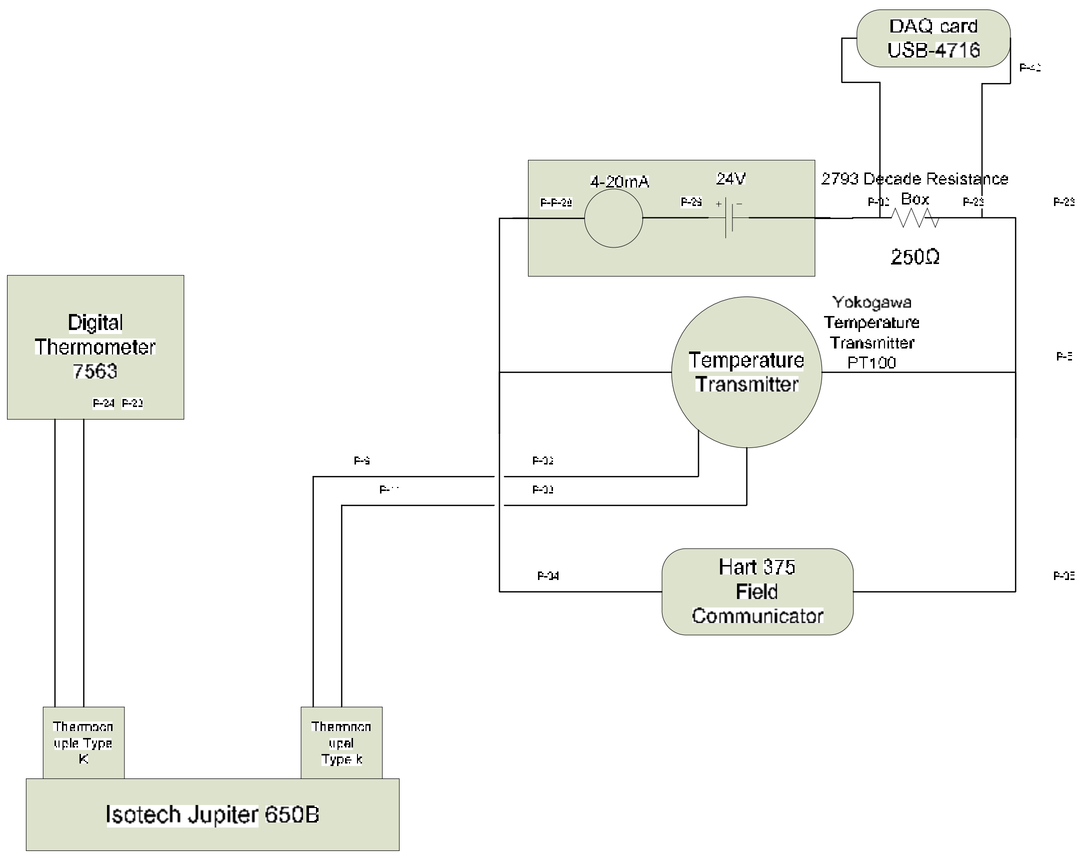

Figure 3.2: Basic Instrument Connection

Instrument part as in Figure 2 consists of Digital Thermometer 7563, RTD, Isotech Jupiter 650B, Yokogawa Digital Manometer MT220, Decade Resistance Box, Yokogawa Temperature Transmitter PT100, and Hart 375 Field Communicator. Thermocouple type K is used as an input device to detect temperature changes. Type K (chromel–alumel) is the most commonly used general purpose thermocouple. It is inexpensive and, owing to its popularity, available in a wide variety of probes. They